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Queensland University of Technology working in partnership with
Queensland Government and Brisbane City Council

# Report - Case Study 2

**A Subtropical Urban Community**
**Investigating Medium to High Density residential typologies**
**By Design Charrette**

**Author**
Rosemary Kennedy
Dec 2009

*Streetscape with Town houses and Flats-over-cars Source: Jim Gall, Gall and Medek Architects*

**Acknowledgements**

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This report is the culmination of the collaborative efforts of many individuals and firms without whose passionate pursuit of well-designed subtropical environments, this project would not have been possible.

Mitchell Brandtman Quantity Surveyors and Construction Cost Planners' involvement was invaluable in providing valid estimates of the cost of construction of various concepts, based on known benchmarks.

Ecolateral Sustainability Consultants have provided a practical and comprehensive analysis of selected concept designs regarding their climate-responsiveness, energy, water and acoustical performance.



**List of Abbreviations**

| | |
|---|---|
| ABCB | Australian Building Codes Board |
| ABS | Australian Bureau of Statistics |
| ASHRAE | American Society of Heating, Refrigeration and Air-conditioning Engineers Inc. |
| BCA | Building Code of Australia |
| BERS Pro | An accepted simulation software program under the ABCB Protocol for House Energy rating Software 2006.1. |
| EER | Energy Efficiency Ratio |
| FECA | Fully Enclosed Area |
| GBCA | Green Building Council of Australia |
| QUT | Queensland University of Technology |
| SEQ | South East Queensland |
| TOD | Transit Oriented Development |
| WSUD | Water-Sensitive Urban Design |

**CASE STUDY 2**

**Creative Team:**

- **Jim Gall, (Team Leader) Director Gall & Medek Architects Pty Ltd**
- Nick McGowan, Landscape Architect, Associate, Visual Planning Assessment LVO, QUT post-graduate student
- Petra Perolini, Lecturer, Interior Design Queensland College of Art, Griffith University
- Geoffrey Walker, Director, Urban Designer Geoffrey Walker and Company
- Anne-Marie Willis, Director, Sustainability/Design TeamDES
- Carl Yap, Property Developer Jalbibi Pty Ltd

***Urban Planning Strategies***

This team emphasised the 'marginal' nature of the study site and developed key urban planning strategies to enhance connectedness to the surrounding community in a variety of integral ways.

- Cross corridor connections
- Urban transect integrating land and built-form to achieve acoustic amenity
- Built form gradient from low to medium rise
- Centrality of site hydrology and ecology. See Figure (i).

- *Cross-corridor connections*

The case study site is physically disconnected from its surrounding community by the rail corridor and future bus lanes and is unlikely to be able to sustain its own commercial retail centre. As a result, it may also be socially disconnected from surrounding suburbs. However, it does offer proximity and access to an extensive 'natural' area, and this is seen as key opportunity for the proposed development to develop a strong relationship with surrounding suburbs.

Developing 'links' instead of barriers in order to achieve better integration socially, physically and environmentally between the proposed development and the surrounding communities is a key driver for this team's approach. In addition to the interconnection at the public transport station, pedestrian and cycling connections between established and proposed neighbourhoods are proposed in at least two other places to overcome the disconnection imposed by the transport corridor. Vehicular infrastructure crossing over the corridor is also considered essential. The philosophy of integration is also applied to approaches to hydrological flows, and to acoustic amenity.

- *Urban transect integrating land and built-form to achieve acoustic amenity*

This team has produced a series of small, low-cost, flexible housing models to form a buffer zone edging the transport corridor. Sites for street-facing row houses are integrated into an earth embankment where their backyards extend to the transport corridor boundary line formed by an acoustic barrier no higher than 2.5m. The public corridor side of the barrier is densely vegetated. The private backyards in the acoustic shadow offer opportunities for gardening, play, water storage, landscaping, growing vegetables or fruit trees and so on. The profile of the integrated acoustic buffer/barrier varies along the length of the corridor depending on the levels. See Fig. (ii).

This approach has acoustic advantages for suburbs on both sides of the transport corridor. The adjacent community on the other side of the rail corridor is not adversely affected by rail noise reflected by the introduction of new structures, and the proposed new development's level of exposure to noise is significantly reduced. Similarly to the Case Study 1 proposal, the journey for rail and bus commuters is characterised by the visual amenity of vegetation rather than the stark impenetrability of lengthy noise barriers.

**Fig. (i) Urban context connections, Gall and Medek Team.**

- *Built form transition from low to medium height*

Several new street-facing building types were developed by the team, achieving a transition both in scale and density throughout the study development site.

The dwellings in the buffer zone are characterised as 'townhouses', and 'flats over cars'. The two types combine in a development model which contains housing, private open space and parking. The 'flats over cars' model offers five ground level parking spaces beneath two first-floor level dwellings which are accessed by a shared stair. The townhouses, better described as row houses, as they are on separate titles and do not share common facilities, have on-site space for parking one vehicle in an open car port; residents may buy or lease covered parking space beneath the flats. Two groups of four street-facing townhouses are configured with two of the 'flats' type to provide a feasible mix of dwellings and parking. A two storey mixed use type combining commercial and residential units is also proposed.

Whimsically categorised by the designers as *buffo townhouseii*, the individual townhouses, on 110m$^2$ sites with narrow frontages, offer flexibility for a variety of uses, including work-at-home opportunities. The building heights vary from two to three storeys depending on the topography. A key component of the small dwelling designs is natural ventilation, supplemented by low velocity fans and roof ventilator systems as determined in each case. See Fig.(viii) below.

The combination of small houses and flats developed for the buffer zone achieve human-scale qualities and give a formed edge to the suburban street, facing to the three-storey "Lofty Loft" (*Loftus Lofteii townhouseii)* detached houses opposite, across a planted median strip.

The three-storey houses transition to six storey apartment buildings. Thus the site transect allows that the multi-storey residences are located in positions where barrier shielding of rail noise is provided by the lower-height buildings. In the team's proposed master plan (Fig. (i)), the six storey buildings form the edges of a boulevard through the centre of the neighbourhood to the natural attraction of the bushland. The ground floor undercroft may be occupied by a variety of uses not programmed in the concept design. These may include parking, commercial activity, semi-public shaded open space.

Throughout, vegetation is an integral part of the suburban experience with space in the street reserve and on private properties for plants and shade trees to grow. This deliberate planting strategy will impact positively on the overall site microclimate, assisting in moderating solar radiation and encouraging air flows. It will also provide a relatively comfortable environment for pedestrians and cyclists. Coupled with numerous front doors on the street, and parking bringing people to the fronts of houses, the foundations for a lively street are laid.

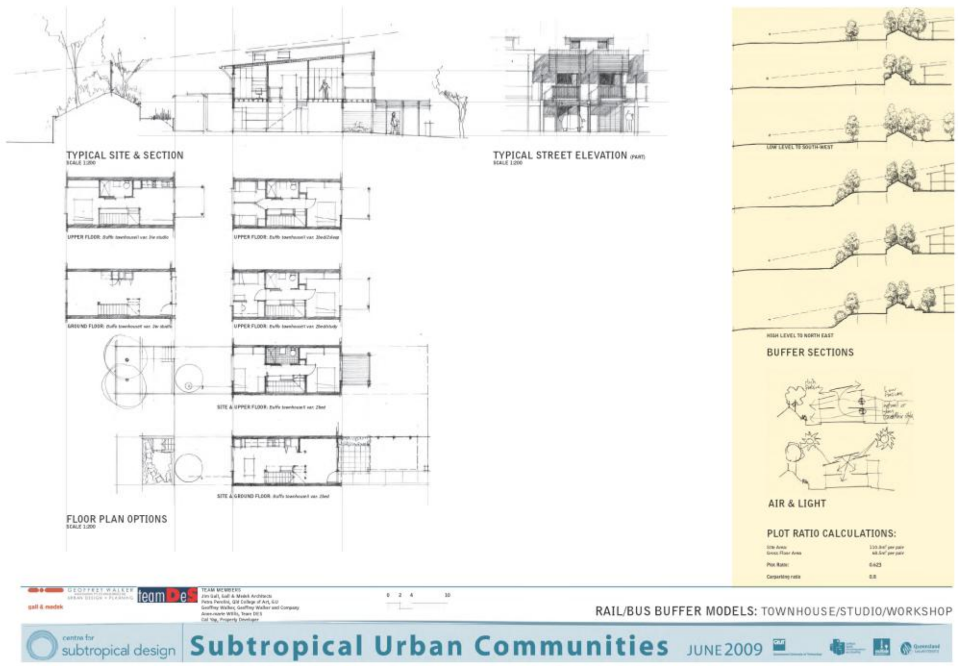


**Fig. (ii)Townhouse/Studio/Workshop Buffer model, Gall and Medek Team**

- *Centrality of site hydrology and ecology*

The development site is on the edge of a natural area which flows to wetland of variable quality. The designers emphasise retention or improvement of natural state flows to conserve or regenerate the wetland. The design intention is that water will be imported, used and taken away to maintain the "natural" balance of the site hydrology.

It is proposed that roof water will be collected and stored, with overflows taken to soakage and a suitable overflow distribution system. This storage will provide management of the hydrological system of the site. While the proposed development will be supplied partially from rainwater storages, the following water sensitive urban design (WSUD) practices are advocated in this approach:

- Car parking areas will have permeable surfaces
- Storm water will be collected into an “agricultural” drainage system for absorption into the site and/or drainage to a suitable overflow distribution system
- Very wide verges and median strips without upstand kerbs or impervious channels are proposed in conjunction with roads and other surfaces requiring strong pavements will drain to “agricultural” drainage/soakage systems and roadside planting areas.
- Courtyards between building rows could be used for dispersal of waste water. As the layouts of rows proposed are very conceptual, the water cycle/system will be an important factor in determining them. Wastewater could be, therefore, partly stored, “delayed” rainfall and partly imported water.

- Plantings with high water uptake (local food production, high maintenance decorative plantings), suitably contained, could be used to absorb some of the excess water from the development and maintain a hydrological balance. In this case a controlled amount of grey water could be treated and used on site – with any excess overflowing to the sewage system.

- *Summary – Urban Planning Strategies Case Study 2*

Achieving a density of 120 du/ha, the overall strategy offers:

- Integrated cross-transport-corridor physical, economic, social and environmental connections.
- A noise abatement strategy that maximises proximity to the transport corridor.
- A range of housing typologies and dwellings types providing a potential degree of diversity of tenure, and of built form transitioning from low to medium height in an incremental and future-focussed model.
- Recognition of the central role of water in overall design.
- Permeable ground surfaces and integrated water sensitive landscape strategy.
- Shaded, active and lively public spaces.

***The Building and Shared Spaces***

Adaptation to climate change is a key driver of this team's urban design and typology design. Intermittent periods of very high temperatures, very heavy rainfall, strong winds and occasional cold snaps are predicted for this region in published climate change models. In the evolving future scenario, energy inputs to buildings will generally be higher than current inputs but will occasionally be low. Strategically, less stable inputs of energy and resources require:

- increased capacity to store energy and resources (for example, water),
- design more for extremes and less for averages,
- shelter to provide greater protection for inhabitants and for their property, and
- shelter for landscape elements (flora and fauna).

These are the guiding principles that underpin the design for 5-6 storey '*Airy Units*' selected for detailed analysis. Water heating will be provided by solar hot water heaters with gas backup. A central system with a single collector array with a re-circulating/storage system and individual hot water meters for each unit or tenancy will be required. Cooking will be fuelled by natural gas or LPG. Natural daylight will be utilised as much as possible and general lighting will be kept to a minimum supplemented by easy to control task specific lighting.

For energy generation, a grid connected, photovoltaic system is proposed. Its capacity will be based on 2 kW per dwelling plus additional capacity to take into account energy use for shared spaces around the building. A battery system will be included to operate as a small uninterruptible power supply for emergency lighting, operation of pumps and ignition of gas stoves, gas heating and gas hot water systems in case of temporary power loss.

The narrative provided by the team notes that landscape plantings close to the buildings will have some formality. They will be based on and probably exhibit endemic species from a range of the vegetation systems of the surrounding area. They may also include small, highly formalised and highly contained plantings of introduced species (e.g. Lemon bushes, *Camellia japonica* and other non-invasive species). The Gall team recommends that a list of Landscape Plantings should be prepared based on a Queensland Herbarium search of locally endemic species.

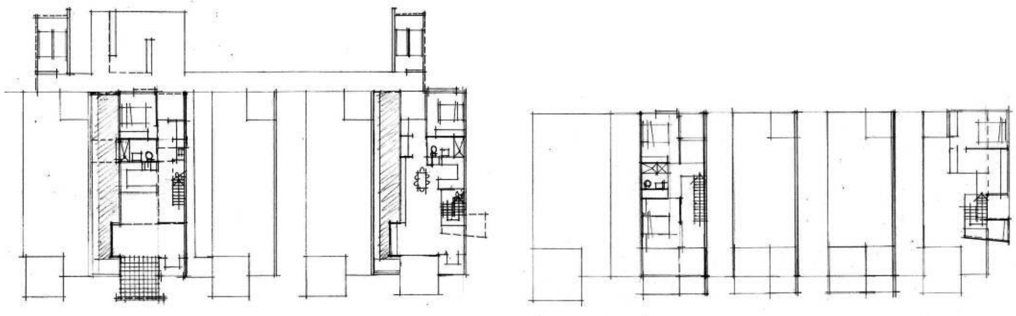

**Fig. (iii) Airy Units Level 5 and 6 Plans, Gall and Medek Team**

Table 1. below describes the parameters of the Airy Units typology.

| **Typology** | **Single-loaded gallery access / stacked apartments** |
|---|---|
| **Scope** | Undercroft parking and retail at ground level, with five levels of residential apartments above for a total of twenty units. Levels 1 to 3 contain 5 units on each level. Pairs of units are separated by breeze ways. Five double storey townhouses accessed at level 5 are also separated by breezeways. Each level also has a shared semi-outdoor space. |
| **FECA** | 2,133m$^2$ |
| **Cost estimate** | $5,312,000.00 exc GST based on concept design |
| **Rate / sq m** | $2,490/ m$^2$ |
| **Comparable range** | $1,844/m$^2$ to $2,660/m$^2$. |
| **Allowances overall** | $100,000 for hard and soft landscaping<br>$30,000 for rainwater tanks |
| **Allowances per apartment** | $20,000 Solar panels<br>$2,500 Whitegoods<br>$7,150 Kitchen cabinetry – laminated bench tops |
| **Apartment types** | 20 units made up of 6 x 1 bedroom/1 bathroom; 9 x 2 bedroom/2 bathroom; and 5 x 3 Bedroom/two bathroom double level.<br>All are cross-ventilated |
| **Vertical access** | One lift in the building and two sets of stairs. |
| **Car park** | The car park is at ground level, is enclosed and naturally ventilated. |
| **External walls and party walls** | Tilt-up concrete panels with furring channels, insulation (polystyrene R1.5) and metal cladding fixed to external face.<br>Shaded external walls in the breezeways are insulated internally and lined internally with plasterboard or 6mm hoop pine hmr* plywood. *hmr – highly moisture resistant. |
| **Roof construction** | Steel framed with coated steel roof sheeting insulated with R3 Polyester/ cotton or wool ceiling batts. Terrace roofs are concrete with R3 to ceilings under. |
| **Internal walls** | Timber framed, lined with 6mm hoop pine hmr* plywood. |
| **Ceiling heights** | Various - minimum 2.7 m |
| **Typical finishes** | Floors: Linoleum to all living areas, tiles to wet areas and carpet to bedrooms<br>Medium quality finish for example, laminated kitchen benchtops |
| **Windows** | Standard windows and sliding glass doors, aluminium framed. |
| **Mechanical ventilation** | Bathrooms are naturally ventilated. |
| **Balustrades** | Moveable screens |
| **Fire Sprinklers** | Not required |

**Table 1. Parameters for concept cost estimate, Case Study 2 Typology, Single-loaded gallery access / stacked apartments**

- *Notes on construction costs*

The concept estimate* for this scope of work compares reasonably with other competing projects at $2,490/m².

The development has been designed on a structural grid that provides an efficient set of spans for roof and floor framing timbers and for reinforced concrete structures, minimising the volume of materials required. The passive thermal performance of the building and its physical impact on the site were important determinants of the construction materials selection.

A further sound abatement strategy, recommended as a result of the acoustic analysis, that was not included in the cost estimate is the addition of sound absorbing material (such as perforated metal) to line the external surfaces in the breezeways between units.

**Fig (iv) Six Storey Airy Units, View from Street, Gall and Medek Team**

- *Findings of the ESD Analysis*

The one and two bedroom apartment configuration that occurs on levels 1-3 of the 'Airy Units' building was analysed. Surrounding buildings were taken into account and assumed to be of similar height and scale in the model. While Gall and Medek's narrative suggests that apartments are likely to be aligned on NW and NE facing orientations, the orientation modelled by Ecolateral** is for the south-facing balconies. The performance of both orientations would be similar, providing modification of external shading was adequately designed. Findings of the ESD Analysis of the 'Airy Units' building are summarised in Table 2 below.

| Factor | Performance |
|---|---|
| **Degree of thermal comfort** | Results indicate that average internal temperatures fall within the acceptability ranges throughout the year. Appropriate insulation and control of natural and fan-assisted ventilation will minimise the amount of heating required in winter.<br>The shared access corridor on the northern side offers shading advantages to the units.<br>The common area on each level provides protection to the units south of it. |
| **Natural ventilation** | All units have at least three external faces. The design solution proposed allows for air flow both within and around units even when there is no breeze at all. Window sizes and positioning creates pressure differences between inside and outside that are adequate to drive some air exchange. Generally, the wing-style window shades act like a scoop and draw prevailing breezes through internal spaces. |
| **Availability of daylighting** | Interiors are generally well day-lit, however the central kitchen space in the two-bedroom unit is likely to require artificial lighting during the day. |
| **Predicted energy rating** | Adjoining one and two bedroom units on intermediate floors were modelled. With ceiling fans, the one-bedroom unit achieves an adjusted star rating of 8.0, while the two bedroom unit achieved an adjusted 7.5 star rating. The two-bedroom unit without adjoining neighbours achieved 7.0 stars. |
| **Energy consumption** | Average annual energy consumption density per square metre for the overall building and site is calculated as 151kWh/m$^2$/annum. If air-conditioning is used, a 27% increase in energy use to 192kWh/m$^2$/annum is predicted. (see Ecolateral report p14, and p42 for explanation) |
| **Renewable energy** | The concept design suggests offsetting power consumption using solar power, A 2kW option for each unit would require 31.4m$^2$ per dwelling. Alternatively, solar hot water systems can achieve a 25% offset of consumption with 10% of the site area or 5.7m$^2$ per dwelling. |
| **Acoustic amenity** | Despite performing well in achieving a balance between thermal conditions, energy consumption and natural lighting – acoustically, the design is at risk of introducing negative effects. Sound may become 'stuck' and bounce between units in the breeze way. Should this occur, people are likely to close their windows to keep the noise down, at the same time reducing the intended natural ventilation. A solution subsequently proposed by the team is to line the external walls, window 'wings' and the underside of the soffit above with sound-absorbing material such as perforated metal. |
| **Average water consumption** | Based on the number and type of dwellings in the development, the average annual water demand has been calculated as 108,198 L/dwelling per annum – an average of 104L/person per day. |
| **Other factors which affect overall environmental performance** | Landscape elements should provide a relatively comfortable microclimate for the site, with plantings reducing the 'heat island effect' that large exposed areas of concrete or asphalt have the potential to generate. |

**Table 2. ESD Evaluation for Case Study 2 Typology, Single-loaded gallery access / stacked apartments**

- *Liveability*

A key component of this approach is establishing a maintenance regime to keep building systems functioning efficiently. To do this a users' guide will assist occupants to understand and use the building systems to reduce consumption of energy and water and other environmental impacts to designed levels or below.

Occupants will be able to manage natural ventilation by easily responding to conditions (such as rain, extreme heat, high winds etc). The nature of the plan, with breezeways running between units, means that each unit has a high proportion of external walls, rather than shared walls with neighbours. Ordinarily this, coupled with a relatively high glazing to floor area ratio might normally lead to a poorer thermal performance, however, good orientation, appropriate shading, and insulation to external walls ensure a high level of comfort for the occupants. Noise transfer between units via open windows into the common breezeways could compromise privacy. This issue is recommended to be addressed by cladding the external walls and soffits with sound-absorbing material.

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***Modelling – Construction Costs**

Quantity Surveyors and construction cost consultants Mitchell Brandtman carried out concept estimates for the selected designs prepared by each creative team, using the cost/m2 Fully Enclosed Covered Area (FECA) as the methodology. Elemental areas for the various project components were calculated from the drawings supplied. Assumptions and clarifications regarding the scope of work and quality of finishes were identified, and appropriate costs per square metre were applied to the relevant quantities, utilising Mitchell Brandtman's cost records for comparable developments. The cost estimates are based on procurement via a tendered lump sum type building contract. The land component and development costs such as professional fees, and authority fees, charges and contributions are not included in the estimate.

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****Modelling – ESD Analysis**

Ecolateral Sustainability Consultants were engaged to model and undertake an integrated analysis of four typical buildings (one concept selected from each creative team) and typical dwellings within them. All case studies are mid-rise apartments, four to eight storeys high. Expected performance in terms of: thermal comfort, natural ventilation, day-lighting, and energy rating based on predicted energy consumption; acoustics; and water management was measured. Measures and benchmarks used in this analysis are provided in Ecolateral's detailed report. The following information is provided for clarity.

| **Parameter** | **Measure** |
|---|---|
| Thermal comfort | ASHRAE Standard 55-2004 *Acceptable operative temperature ranges for naturally conditioned spaces* is used. An acceptability range where 8 out of 10 people are satisfied is used. |
| Natural ventilation | Effective design ventilation rates for minimum and maximum external wind speed conditions for Brisbane according to the Test Reference Year weather data are used. |
| Availability of daylighting | Measurements are taken at the working plane (1.5m above floor level) for 12 noon on 21 September under an overcast sky. |
| Predicted Energy Rating | This is an assessment of the capability of the *fabric* of the building to provide for the thermal comfort of the occupants. The BERS Pro software program is used, under the conditions specified by the ABCB.<br>Star rating adjustment. Dwellings under 200m$^2$ are given an area adjustment rating that increases their star rating. The smaller the floor area, the bigger the adjustment and the more the star rating is increased. For houses over 200m$^2$ the opposite is the case. |
| Energy Consumption | The *Green Star Multi-Unit Residential Green House Gas Emissions Guide* is used to calculate typical energy consumption for typical units. Then the anticipated energy density of the typology is calculated. This is not a measure of energy consumption per square metre of living space, rather it is the energy density predicted for the scope of development. Energy consumption of developments will vary based on the number of dwellings per site area, and heating and cooling requirements as measured by BERS. With a higher development density the energy density of the site increases. However the developed design solution will influence the space conditioning requirements, and can result in different energy densities between sites with the same development density. |
| Renewable Energy | Area calculations are based on Thin film Amorphous Photovoltaic solar panels – these are the most shade tolerant, have least embodied energy, most power efficiency, greatest insulation benefits, but are the least space efficient of PV panels currently available on the market. |
| Acoustic Amenity | Desktop review only of acoustics and environmental noise considerations. |